5.

**MIN**: +7x12 + 6x14 + 3x23 + 4x24 + 5x32 + 9x43 + 8x52 + 5x54

**Subject** **to**:

-X12 – X14 = -5 (**Node 1**)

+X12 + X52 + X32 - X23 – X24 = +4 (**Node 2**)

-X32 + X23 + X43 = +8 (**Node 3**)

+X14 + X24 + X54 - X43 = +0 (**Node 4**)

-X52 – X54 = -7 (**Node 5**)

Xij >= 0 for all *i* and *j*

**Network** **Representation**:

-5

1

2

+7 +6

+4 +0

4

3

5

+3

+9

+5

+8

+4

+8

+5

-7

14.

**MIN**: 5x12 + 13x13 + 45x15 + 105x17 + 27x23 + 19x24 + 50x25 + 95x27 + 14x34 + 30x35 + 32x36 + 14x43 + 35x45 + 24x46 + 35x54 + 18x56 + 25x57 + 24x64 + 18x65 +17x67

**Subject to**:

-X12 – X13 – X15 – X17 = -1 (**Node 1**)

+X12 – X23 – X24 – X25 – X27 = 0 (**Node 2**)

+X13 + X23 + X43 – X34 – X35 – X36 = 0 (**Node 3**)

+X24 + X34 + X54 + X64 – X43 – X45 – X46 = 0 (**Node 4**)

+X15 + X25 + X35 + X45 + X65 – X54 – X56 – X57 = 0 (**Node 5**)

+X36 + X46 + X56 – X64 – X65 – X67 = 0 (**Node 6**)

+X17 + X27 + X57 + X67 = 1 (**Node 7**)

Xij >= 0 for all *i* and *j*



2

1



4

5

3

7

6



18.

**Max**: X71

**Subject to**:

+X71 – X12 – X13 – X14 = 0 (**Node 1**)

+X12 – X23 – X25 = 0 (**Node 2**)

+X13 + X23 + X43 – X35 – X36 – X37 = 0 (**Node 3**)

+X14 – X43 – X46 = 0 (**Node 4**)

+X25 + X35 – X57 = 0 (**Node 5**)

+X36 + X46 – X67 = 0 (**Node 6**)

+X37 + X57 + X67 – X71 = 0 (**Node 7**)

**With the following bounds on the decision variables**:

0 <= X12 <= 8

0 <= X13 <= 9

0 <= X14 <= 7

0 <= X25 <= 10

0 <= X36 <= 7

0 <= X37 <= 9

0 <= X23 <= 7

0 <= X43 <= 6

0 <= X35 <= 8

0 <= X46 <= 9

0 <= X57 <= 9

0 <= X67 <= 11

0 <= X71 <= ∞

20.

**MIN**: 12x12 + 8x13 + 15x14 + 9x23 + 16x25 + 6x34 + 7x35 + 12x54

**Subject to**:

-X12 – X13 – X14 = -15 (**Node 1**)

+X12 – X23 – X25 = -15 (**Node 2**)

+X13 + X23 – X34 – X35 = 0 (**Node 3**)

+X14 + X34 + X54 = +20 (**Node 4**)

+X25 + X35 – X54 = +10 (**Node 5**)

Xij >= 0 for all *i* and *j*

24.

b. $1,863

c. $3,280

d. If travel is permissible in either direction between, it would lower the cost to get to City 12 because it would not take as long to get to City 12 as it would usually. In some cases, it may not affect the cost at all because the movers are trying to get from City 1 🡪 City 12, and they seem to be able to do that efficiently with the way the network model is set now. There are no barriers to entry from get to City 9 from City 6, but with travel being permissible in either direction, it will allow for the movers to get back to City 1 cheaper as well.

26.

**Max**: X61

**Subject to**:

+X61 – X12 – X13 – X14 = 0 (**Node 1**)

+X12 – X24 – X25 = 0 (**Node 2**)

+X13 – X35 – X34 = 0 (**Node 3**)

+X14 + X24 + X34 – X46 = 0 (**Node 4**)

+X25 + X35 – X56= 0 (**Node 5**)

+X56 + X46 – X61 = 0 (**Node 6**)

**With the following bounds on the decision variables**:

0 <= X12 <= 800

0 <= X13 <= 650

0 <= X14 <= 700

0 <= X24 <= 725

0 <= X34 <= 625

0 <= X25 <= 700

0 <= X35 <= 750

0 <= X56 <= 900

0 <= X46 <= 725

0 <= X61 <= ∞

4

2



6

1



5

3

32.

**MIN**: 1x12 + 3x13 + 2x14 + 4x25 + 3x26 + 2x36 + 2x46 + 3x47 + 4x49 + 1x56 + 3x58 + 3x59 + 2x69 + 2x79 + 3x710 + 2x811 + 1x911 + 2x912 + 3x1011 + 5x1012 + 2x1112

**Subject to**:

-X12 – X13 – X14 = -1 (**Node 1**)

+X12 – X25 – X26 = 0 (**Node 2**)

+X13– X36 = 0 (**Node 3**)

+X14– X46 – X47 – X49 = 0 (**Node 4**)

+X25 – X56 – X58 – X59 = 0 (**Node 5**)

+X26 + X36 + X46 + X56 – X69 = 0 (**Node 6**)

+X47 – X79 – X710 = 0 (**Node 7**)

+X58 – X811 = 0 (**Node 8**)

+X49 + X59 +X69 + X79 – X911 – X912 = 0 (**Node 9**)

+X710 – X1011 – X1012 = 0 (**Node 10**)

+X811 +X911 + X1011 – X1112 = 0 (**Node 11**)

+X912 + X1012 + X1112 = 1 (**Node 12**)

Xij >= 0 for all *i* and *j*